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Co-occurrence of *Metoicoceras geslinianum* (D'ORBIGNY) and *Vascoceras cauvini* CHUDEAU (Cretaceous Ammonoidea) in the southern Negev (Israel) and its stratigraphic implications

by ZEEV LEWY, WILLIAM JAMES KENNEDY and GORDON CHANCELLOR*

with 4 figures and 1 table

Abstract. *Metoicoceras geslinianum* (D'ORBIGNY), an Upper Cenomanian indicator in Boreal faunas occurs in the '*Kanabiceras*' Zone of Israel, associated with *Vascoceras cauvini* CHUDEAU, a widely recorded Tethyan index fossil that has generally been regarded as Lower Turonian. This provides the first direct evidence for the Cenomanian age of part of the Lower Turonian in Tethys, as well as the undoubted occurrence of true vascoceratids in the late Cenomanian.

1 Introduction

Regional differentiation of Boreal and Tethyan ammonite faunas results in interregional correlation problems at several levels in the mid-Cretaceous. These problems are particularly acute around the level of the Cenomanian-Turonian boundary, due to the virtual absence of the predominantly Tethyan vascoceratids in Boreal faunas and a similar absence or rarity of key Acanthoceratinae, Euomphaloceratinae and Mammitinae at critical levels in Tethyan sequences. Several authors have attempted correlations around this boundary on indirect or disputed evidence: BERTHOU & LAUVERJAT (1974 a, b, 1975, 1978 a, b) and LAUVERJAT & BERTHOU (1974) have, in a series of papers, suggested that the 'Lower Turonian' *Vascoceras gamai* Zone of the Iberian Peninsula was actually Upper Cenomanian on the basis of benthic foraminifera present, whilst MOJICA & WIEDMANN (1977) have firmly refuted this view. KENNEDY & JUIGNET (1977) redescribed *Ammonites diartianus* (D'ORBIGNY) showing it to be a *Vascoceras* and inferring it to be Upper Cenomanian, although admitting the holotype to be a reworked phosphate in younger sediment. COOPER (1979), unwilling to accept Cenomanian *Vascoceras*, made it type species of a new genus, *Provascoceras* COOPER, 1979.

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WRIGHT & KENNEDY (1981) subsequently illustrated a second, undoubtedly indigenous specimen from the Upper Cenomanian *Metoicoceras geslinianum* Zone of southern England. They also described *Nigericeras* and *Thomasites* species from a horizon slightly higher than that of *Metoicoceras geslinianum* but below the *Neocardioceras juddii* Zone and thus in their view also Upper Cenomanian; they pointed out that *Nigericeras* and *Thomasites* are held to be exclusively Lower Turonian in the Tethyan Realm. CHANCELLOR, REYMENT & TAIT (1977) and CHANCELLOR (1982) noted a fragment of the Upper Cenomanian (in a Boreal sense) genus *Metoicoceras* in the matrix of a *Vascoceras* from Coahuila, Mexico, but COOPER (1979) again rejected this, preferring to identify the fragment as a Lower Turonian *Quitmaniceras* POWELL, 1963. FREUND & RAAB (1969) recorded vascoceratids with the generally Upper Cenomanian *Kanabiceras* in their lowest Turonian (Zone Ti), but COOPER (1978, p. 110) suggested the latter to be juvenile *Schindewolfites* or *Kamerunoceras*, genera he believed restricted to the Turonian.

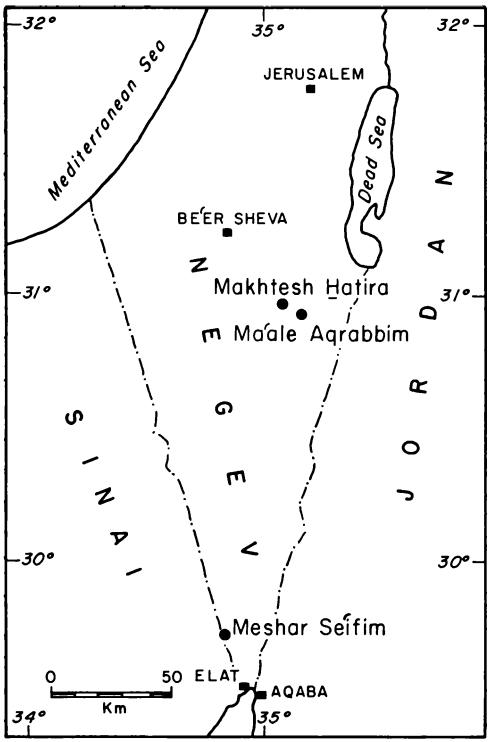

Fig. 1. Locality map showing sections mentioned in the text.

HOOK & COBBAN (1981), AMARD, COLLIGNON & ROMAN (1983) and BENGTSON (1983) have also recorded associations of Boreal Upper Cenomanian and Tethyan 'Lower Turonian' ammonites, but in most of the above cases, there is dispute or ambiguity, and in no instance do precisely placed indices of Boreal and Tethyan zones co-

occur (HANCOCK & KENNEDY 1981). In these disputed circumstances we record here the unequivocal co-occurrence of the Boreal Upper Cenomanian index fossil *Metoicoceras geslinianum* (D'ORBIGNY) and the Tethyan Lower Turonian index fossil *Vascoceras cauvini* CHUDEAU in the Negev, southern Israel (Fig. 1). The stratigraphic context of the occurrences is described below, after which we discuss the implications of the record for the correlation of Boreal-Tethyan Cenomanian/Turonian boundary sequences.

2 Stratigraphy

The Cenomanian-Turonian boundary lies within the Ora and Derorim Formations in the Negev. The Ora Formation (Ora Shale of FREUND, 1962) in the southern Negev consists of nearly a hundred meters of clay, marl and some limestone beds (BARTOV et al. 1972). The Derorim Formation in the northeastern Negev attains a thickness of nearly 20 m and is made up of chalk, marl and limestone beds. These two formations are very fossiliferous and the macrofossils weather out of the soft sediment and are easy to observe and to collect.

During a survey of the Upper Cenomanian and Lower Turonian ammonites in southern Israel two sections were carefully studied to detect the precise position of the Cenomanian-Turonian boundary within the lower part of the Ora Formation: at Meshar Se'ifim (18 kms north of Elat, Israeli grid 137/902; Figs. 1, 2) and within the lower part of the Derorim Formation at Ma'ale Aqrabbim (northeastern Negev, Israeli grid 1637/0350; Figs. 1, 3).

The shaly Ora Formation overlies a calcareous sequence of the Hazera Formation (BARTOV et al. 1972). In the Elat region the upper part of the Hazera Formation consists of 0.5–1.0 m of platy limestone overlain by 1 m of fine-grained, fossiliferous limestone with *Neolobites vibrayeanus* (D'ORBIGNY) and *Deltoidonautilus mermeti* (COQUAND) at the top. This limestone is followed by marl and clay (nearly 1 m) and a ferruginous dolostone layer (10–20 cm), which forms the top of the formation.

The base of the Ora Formation (Fig. 2) is a greenish clay (nearly 8 m) containing large and thick-shelled *Costagyra olisiponensis* (SHARPE), the attachment areas of some of which are moulds of *Eucalycoceras rowei* (SPATH) (GSIM 7983) and *Calycoceras* sp. The succession becomes more calcareous upwards, grading into marl, argillaceous limestone, and ultimately, a limestone complex 2 m thick. This limestone is well bedded and divided into smaller 40–60 cm units each of which is friable and argillaceous below but well-cemented at the top. Ammonites were found in the upper two of these units; the lower one yielded smooth and ribbed *Vascoceras cauvini, Metoicoceras geslinianum* (Fig. 4) and *Kanabiceras* sp. The upper unit contains *V. cauvini* only. It is overlain by clay and marl (approx. 5 m) with *Vascoceras pioti* (PERON & FOURTAU) (not found in situ) and 1.5 m of limestone with *Choffaticeras securiforme* (ECK). Above follow marls and clays (1.0–1.5 m) capped by a 0.5 m limestone with *Choffaticeras quaasi* (PERON), 1.5–2.0 m of marl overlain by highly fossiliferous limestone beds (4–6 m) containing a very diverse ammonite fauna of the *Chofatticeras luciae trisellatum* Zone (Fig. 2).

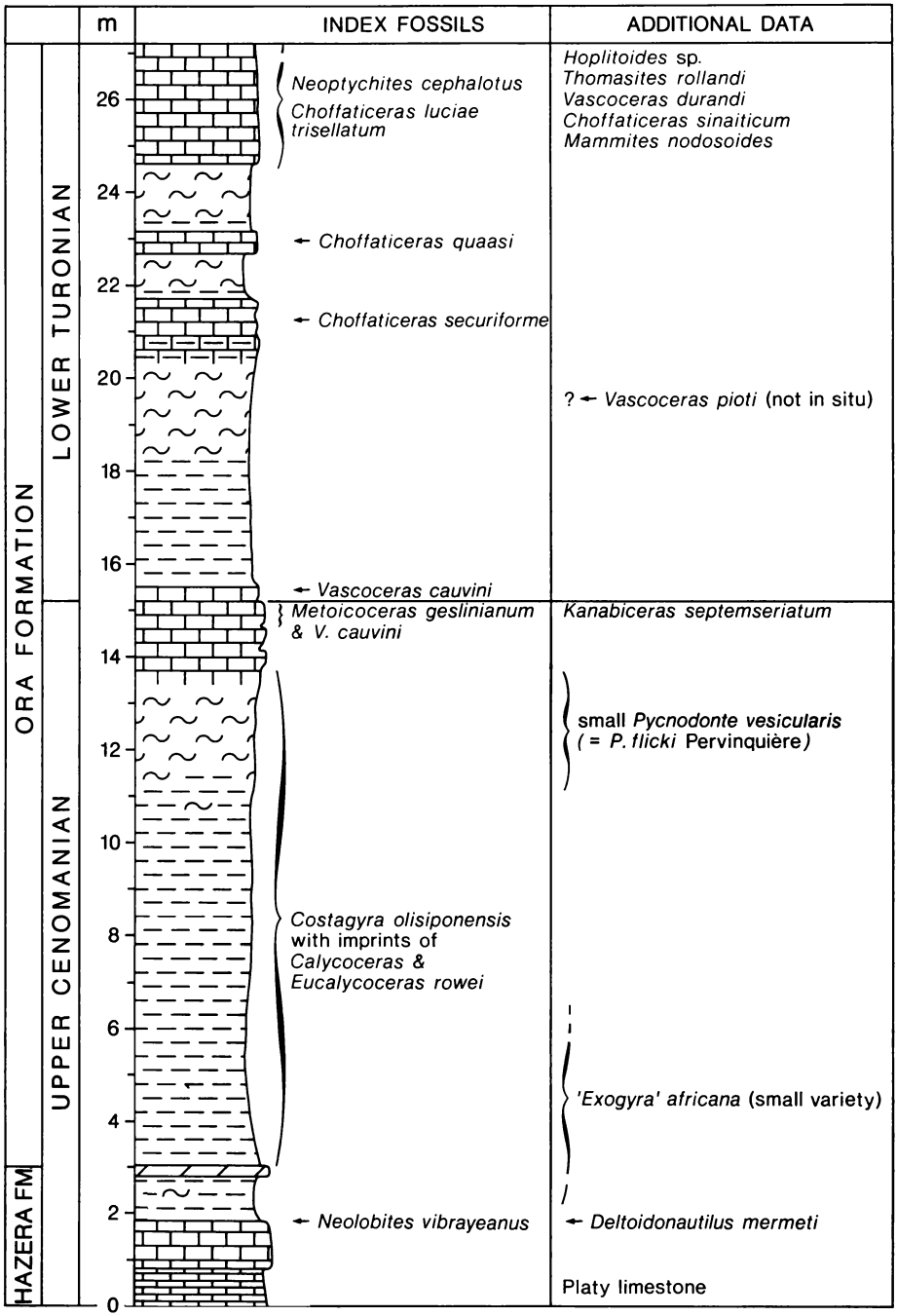

Fig. 2. The succession at the top of the Hazera Formation and in the lower part of the Ora Formation at Meshar Se'ifim (18 kms north of Elat), southern Israel (coordinates 137/902).

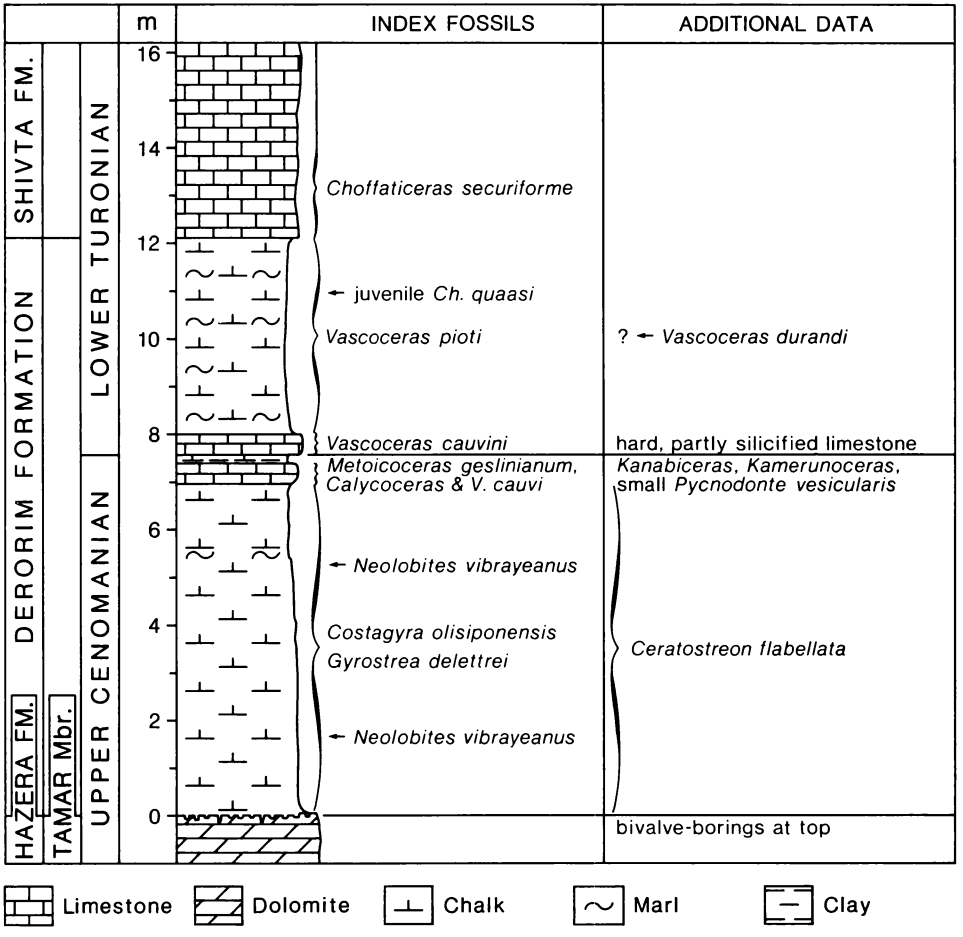

Fig. 3. The succession in the Deroim Formation and the lower part of the Shivta Formation at Ma'ale Aqrabbim, northeastern Negev, Israel (Coordinates 1637/0350).

At Ma'ale Aqrabbim (Fig. 3) the Derorim Formation overlies a dolostone, Tamar Member of the Hazera Formation, the top surface of which is a hardground with bivalve borings and limonite impregnation. This hardground is overlain by white chalk and chalky limestone (7–8 m) rich is oysters and a few other bivalves, as well as *Neolobites vibrayeanus* at two levels. The chalky unit is followed by a yellow-pink chalky limestone (40–50 cm) containing *Metoicoceras geslinianum, V. cauvini,* fragmentary, corroded *Calycoceras* sp. and abundant poorly preserved moulds of a *Kanabiceras/Kamerunoceras*-like ammonite. This chalky limestone is overlain by 40–50 cm of a hard bioclastic limestone, locally silicified, containing abundant *V. cauvini* as the only ammonite. This hard limestone is overlain by a pinkish chalk and marl complex nearly 4 m thick, containing the ammonites *Vascoceras pioti* and juvenile *Ch. quaasi.* Above

follows a bioclastic limestone complex with *Ch. securiforme,* which marks the base of the Shivta Formation (Fig. 3).

The ammonite succession at Ma'ale Aqrabbim is thus identical to the one described from the Elat region. A final locality with *Metoicoceras geslinianum* is alongside the road from Yeroham to Oron where it cuts through the southern limb of the Makhtesh Hatira anticline (Israeli grid: 1526/0405; this locality is also referred to as Hamakhtesh Hagadol or the Kurnub anticline in the literature; see Fig. 1). The sequence here corresponds to the Derorim Formation in the northern Negev sequence and its transition southwards into the Ora Formation. The two *Metoicoceras* (Geological Survey of Israel Collections nos. M-7982) were found loose below outcrops spanning the *Kanabiceras* sp. to *C. securiforme* Zones.

3 Discussion

The sections described above show beyond doubt that *Metoicoceras geslinianum* and *Vascoceras cauvini* co-occur in Israel. On the basis of this, and other records, we propose the correlation of the standard north-west European Boreal zonation and the Israeli Tethyan sequence shown in Table 1. It is not, of course, possible to correlate the limits of zones, but evidence for at least partial contemporaneity is as follows:

1. The *vibrayeanus* Zone is in part equivalent to the *guerangeri* Zone on the basis of the occurrence of *N. vibrayeanus* in the latter Zone at Saumur and in the Beausset region in France (KENNEDY & JUIGNET 1981).
2. The *Calycoceras* sp. Zone correlates with the *guerangeri* Zone on the basis of the occurrence of *Eucalycoceras rowei* in both, as described above.
3. The *geslinianum* and *Kanabiceras* sp. Zones are correlated on the basis of the common occurrence of *M. geslinianum* described above.
4. The *cauvini* and *juddii* Zones cannot be directly correlated between Europe and Israel. The occurrence of *Pseudaspidoceras* of *pseudonodosoides* (CHOFFAT) type in the *cauvini* Zone in Israel and in association with *Neocardioceras juddii* (BARROIS & GUERNE) in Texas (HOOK & COBBAN 1981) provides an indirect link.
5. The *pioti, securiforme* and *quaasi* Zones possess no elements in common with the European Boreal succession.
6. The *luciae* and *nodosoides* Zones are linked by the common occurrence of *Mammites nodosoides* (SCHLÜTER) (Israel: FREUND & RAAB 1969 and new collections; Europe: WRIGHT & KENNEDY 1981 plus references).

Fig. 4. A–D, H. *Metoicoceras geslinianum* (D'ORBIGNY). A–B, GSI Collections, Ora Formation, Meshar Se'ifim, Israel; C–D, GSI Collections, Derorim Formation, Ma'ale Aqrabbim, Israel; H, OUM KY1492 locality as for A–B. E–G, *Eucalycoceras rowei* (SPATH). E, GSI M7983, Ora Formation, Meshar Se'ifim, Israel; F–G, J. M. Hancock Collection, Bed C, Cenomanian Limestone, Humble Point, Devon, England. I, *Metoicoceras geslinianum* (D'ORBIGNY) and *Vascoceras cauvini* CHUDEAU. Ora Formation, Meshar Se'ifim, Israel. GSI Collections.
All figures × 1.
GSI = Geological Survey of Israel, Jerusalem.
OUM = Oxford University Museum Collections.

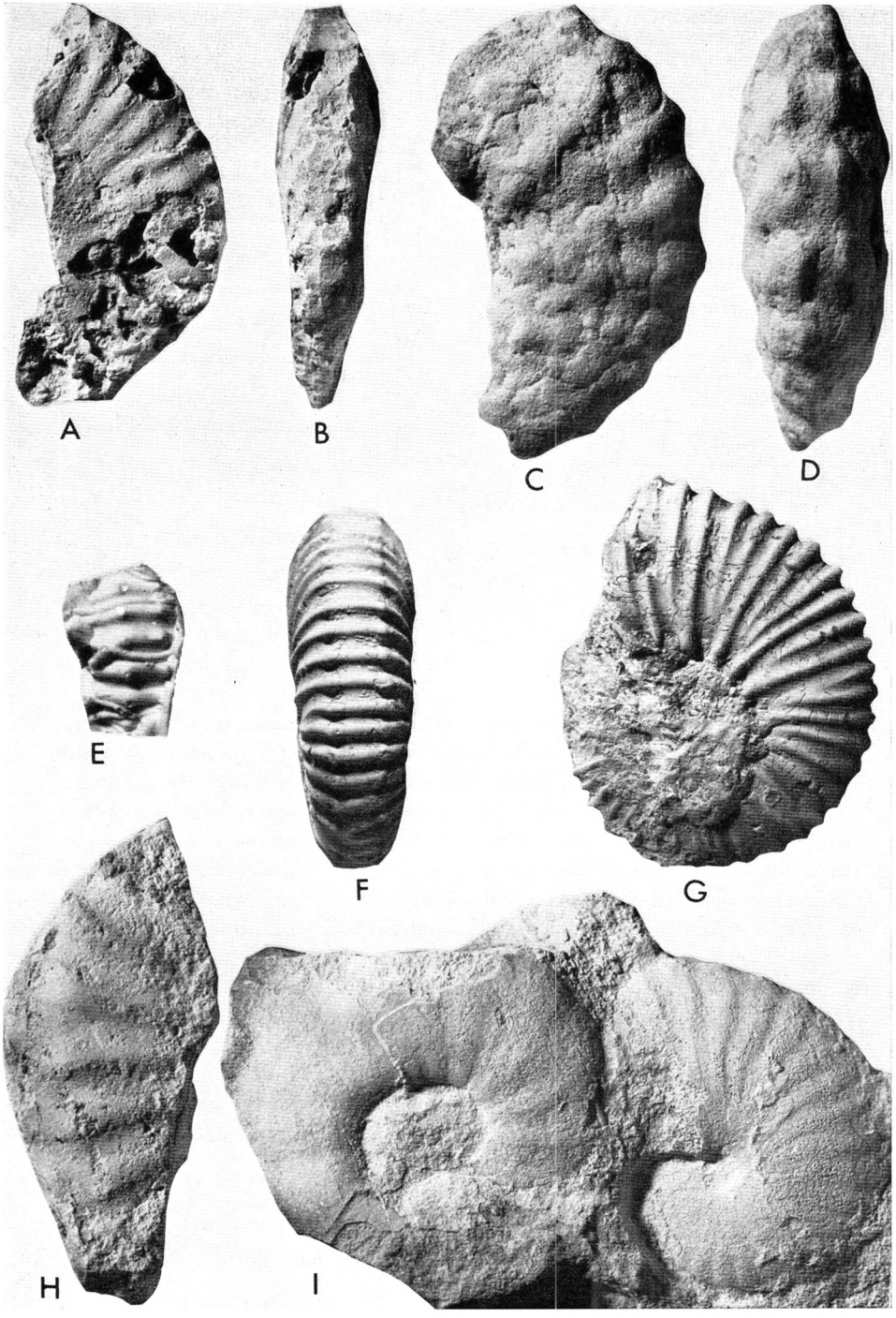
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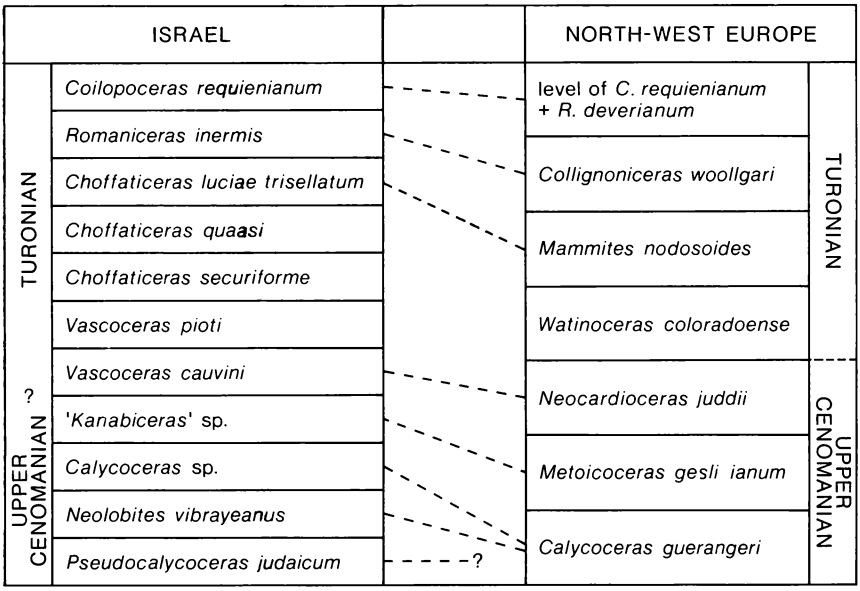
Table 1 Correlation of Upper Cenomanian and Turonian zonal sequences in Israel (FREUND & RAAB 1967, LEWY & RAAB 1978) and western Europe (WRIGHT & KENNEDY 1981, WRIGHT, KENNEDY & HANCOCK 1984).



7. The *woollgari* and *inermis* Zones are linked by the common occurrence of *Romaniceras (Yubariceras)* of *ornatissimum* (STOLICZKA), type (Israel: FREUND & RAAB 1969, LEWY & RAAB 1978, Europe: KENNEDY, WRIGHT & HANCOCK 1980), as well as by a single juvenile *C. woollgari* (MANTELL) found in southern Israel 65 m above the *Ch. luciae trisellatum* Zone (GSI unpublished internal report).
8. The *Coilopoceras requienianum* Zone is equivalent to the level of co-occurrence of the index species and *Romaniceras (Romaniceras) deverianum* (D'ORBIGNY) in Europe. This Zone cannot as yet, however, be placed with confidence into either the *C. woollgari* or *S. neptuni* Zones of the European standard, as discussed by KENNEDY, WRIGHT & HANCOCK (1983). In conclusion, the *Kanabiceras*, rightly, *Euomphaloceras*, Zone of the Israeli sequence is Upper Cenomanian. There is thus no doubt that *Vascoceras cauvini* appears within the Cenomanian. As this species is widely cited as an index fossil for the 'Lower Turonian' in the Saharan region there is need for reappraisal of correlation, palaeogeography and timing of transgressions in this area. There are also phylogenetic results, in particular those of COOPER (1979) which are now seen to be untenable.

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